

CHEMISTRY OF MUSCULAR CONTRACTION

BY

A. SZENT-GYÖRGYI

Department of Biochemistry, University, Budapest



1947

ACADEMIC PRESS INC., PUBLISHERS
NEW YORK, N. Y.

Copyright 1947
By ACADEMIC PRESS INC.

WE
500
\$997c
1947

Published in the United States of America
ACADEMIC PRESS INC.
125 East 23rd Street, New York 10, N. Y.

0021

THE MURRAY PRINTING COMPANY
CAMBRIDGE, MASSACHUSETTS

FOREWORD

This little book contains my *Cameron-Prize* Lecture, held at the University of Edinburgh on July 23, 1946. Having been relieved of the danger of exhausting an audience rather than the subject, the text was completed.

I am conscious that the work to be reported here is very incomplete in many ways. This is because it is still in progress and means the opening up rather than the closing down of a field. The incompleteness of references may be excused by the completeness of my isolation for six years and the lack of a library at my present station.

The following abbreviations will be used:

ATP: Adenosine triphosphate, or adenyl diphosphate.

ADP: Adenosine diphosphate.

AMP: Adenosine monophosphate, or adenylic acid.

DR: Double refraction.

DRF: Double refraction of flow.

UW: Unit weight. For myosin and actin 17,600 g. will be taken arbitrarily as UW, whether such units actually exist or not.

MW: Molecular weight.

IP: Isoelectric point.

If not stated otherwise, my text relates to the cross-striated muscle of the rabbit.

I find it impossible to write on muscle without giving expression to my profound gratitude towards the *Josiah Macy, Jr. Foundation, New York*, whose help enabled me to start this work many years ago, and who came to my help again as soon as hostilities were over. It is equally impossible not to remember its late president, L. Kast, M.D., whose kind interest and encouragement doubled the value of the material help extended. My thanks are due to Professor J. W. McBain from Stanford University for giving me his fountain pen to write this book.

Arosa (Switzerland), August, 1946.

CONTENTS

FOREWORD	iii
INTRODUCTION	1

PART I

Myosin, Actin, and Actomyosin

I. MYOSIN	3
General properties.	3
Metal myosinates.	7
Myosin and water	12
ATP myosinate.	12
Glycogen-myosin compounds.	15
II. ACTIN	17
Metal actinates	19
The G-F transformation	21
III. F-ACTOMYOSIN	24
Metal actomyosinates.	26
Actomyosin and ATP	30
IV. G-ACTOMYOSIN	37
V. A THEORY OF CONTRACTION	38
VI. ENERGY CHANGES IN CONTRACTION	45
VII. ENZYMATIC FUNCTIONS OF MYOSIN AND ACTOMYOSIN	50
ATP-ase and ADP-ase activity. Dephosphorylation and deamination. Protein II.	50
Metals: physical state and enzymatic activity	53
VIII. ADP-CONTRACTION, PROTEIN I, AND FLUOCHROME	58

PART II

Conditions and Reactions in Muscle

I. INTRODUCTION	65
II. REST	68
III. EXCITATION	71
IV. CONTRACTION	73
V. RELAXATION	76
VI. RIGOR AND CONTRACTURE	77
VII. CONTRACTION, FERMENTATION, AND OXIDATION	78
VIII. LIPINS, SMOOTH MUSCLE, HEART MUSCLE, KIDNEY, AND BRAIN	84
IX. ON THE NATURE OF CROSS-STRIATION	88

PART III

The Continuum Theory

I. INTRODUCTION	95
II. INNER PHOTOELECTRIC EFFECT IN PROTEIN	98
III. PHOSPHORESCENCE OF CHROMOPROTEIDS	101
IV. STRUCTURAL AND TIME RELATIONS	105
V. BIOLOGICAL ASPECTS	107

PART IV

Recent Advances

1946-1947

I. MOLECULAR WEIGHT	113
II. ACTIN CONTENT AND ACTIVITY OF MYOSIN	113
III. THE FIXATION OF IONS BY MYOSIN	114
IV. ENZYMATIC ACTIVITY AND CONTRACTILITY OF MYOSIN. PROTINS	119
V. ATP-ASE ACTIVITY OF MUSCLE AT 0° C.	122
VI. ENERGETICS	123
VII. THE CONTINUUM THEORY	125
VIII. CONDITIONS IN MUSCLE	126
IX. THE NATURE OF CROSS-STRIATION	128

PART V

Methods

I. THE PREPARATION OF ATP	133
II. THE PREPARATION OF MYOSIN	135
General remarks.	135
Extraction.	135
Crystallization	137
Further purification.	138
Ammonium sulphate method	139
III. THE SEPARATION OF PROTINS AND MYOSIN	140
The contraction test	140
Protin-free myosin.	140
Cerebroside	142
IV. THE PREPARATION OF ACTIN	142
Further purification	144
V. ACTOMYOSIN THREADS	145
BIBLIOGRAPHY	147
REFERENCES	149